

EVALUATION OF FIELD PERFORMANCE OF RESIDENTIAL FUEL CELLS

Presented by Edward Torrero

**National Rural Electric Cooperative Association
Cooperative Research Network (CRN)**

Arlington, Virginia

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**Awarded Under the NREL/DOE Distributed Power Program
Distributed Power System Integration Research and Development
Cost-shared Competitive Solicitation**

NREL Technical Monitor: Holly Thomas

Research Team Members: NRECA's Cooperative Research Network
Energy Signature Associates, Inc.
Individual Participating Co-ops

Principal Investigator: Edward Torrero CRN Arlington, VA

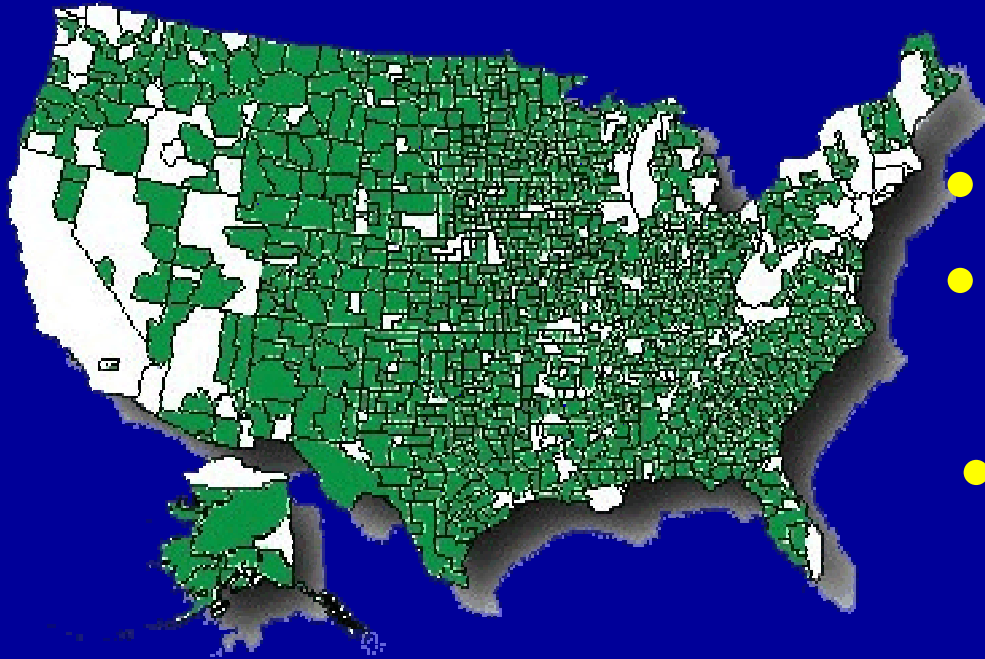
Sub-tier Principal Investigator: Richard McClelland Energy Signature Associates, Inc
Pittsburgh, PA



CRN RFC Demonstration Objectives . . .

- **Ascertain key near-term / long-term DP benefits**
- **Identify and resolve critical DP implementation barriers**
- **Build solid foundation for co-op DP**
- **Benchmark Residential Fuel Cell (RFC) technology for further effort**

Why Co-ops?



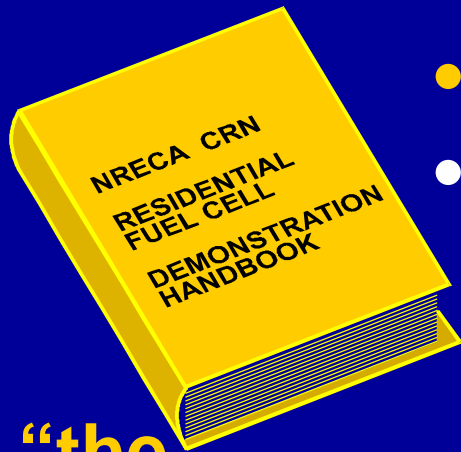
- Customer owned
- Serve 34 million consumers in 46 states → 75 percent of nation's area
- 2.3 million miles of line is close to half of nation's total

Moreover ...

- Growth rate twice that of IOU Electric
- Six customers per line-mile ...vs... 33 for IOU
- Co-ops view DP as needed solution; not a “*Problem*”

Already Accomplished . . .

 RFC DP Application Analysis → Demo Handbook



“the
present
RFC
Bible”

- Demonstration planning, installation, operation
- Identify and manage application barriers including: electrical / fuel / water / thermal recovery / etc.
 - Includes Electrical Interconnect:*
 - Types, analysis, and Issues (GP GI DualMode)
 - Interconnect and PQ verification procedures
- Thermal recovery (CHP) applications, integration, and benefits
- Data collection / instrumentation protocols
- Assess market and application issues

Already Accomplished (cont'd) . . .



Held CRN RFC Training Seminar Program

January 2001						
Denver						
	29	30	31			
	✓	✓	✓			

- 3 days and 15 presenters
- Introduce co-ops to RFC DP
- 60 co-op participants
- 4 preselected manufacturer presentations

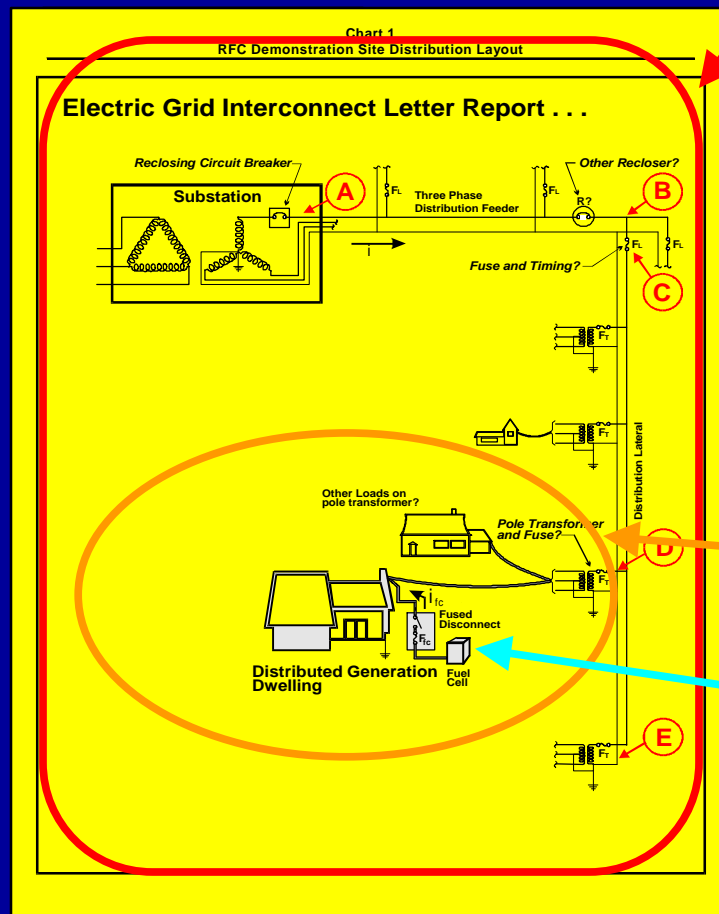
- Included:**
- Assess fuel cell technologies and status
 - Review PEM cell stack and power plant design
(Concerns that a co-op should know about when assessing manufacturers!)
 - Review electrical Interconnect types and issues
 - Examine other key interconnects and barrier concerns *Fuel / Water / Thermal Recovery*
 - Explore customer applications, markets, and related barriers



Already Accomplished (cont'd) . . .

 Developed comprehensive Co-op Letter Reporting protocols and standards:

 Electrical Interconnect LR



Co-op analysis of the grid interconnect that serves the RFC including:

- Voltage
- Nodes and Distances
- Amps and Relative Loads
- Recloser / fuse locations and protective timing
- Other protective components (*relaying, sectionalizers, etc*)

Other loads / customers on interconnect side of pole transformer

Co-op assessment of RFC Interconnect Protocol

Already Accomplished (cont'd) . . .

Developed comprehensive Co-op Letter Reporting protocols and standards:

 Site Selection LR (19 Pages)

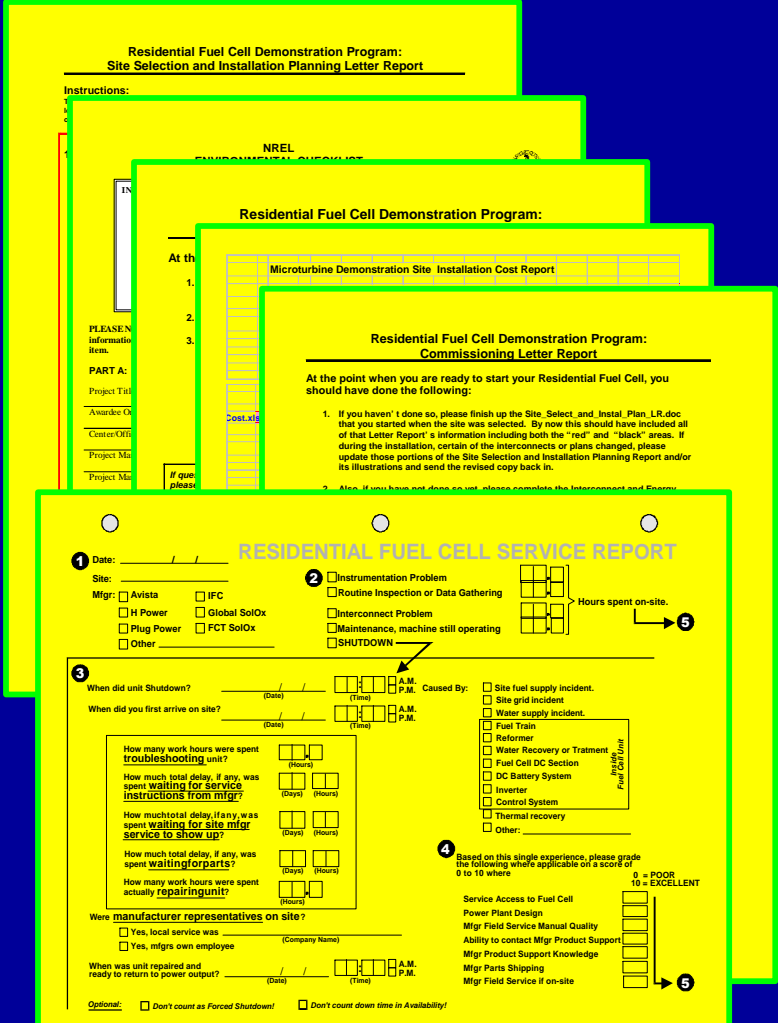
 Environmental Analysis Form (6 Pages)

 Site Energy Survey LR (WWW based)

 Installation Cost Spreadsheet

 Commissioning LR (7 Pages)

 Interconnect / Service Incident Report



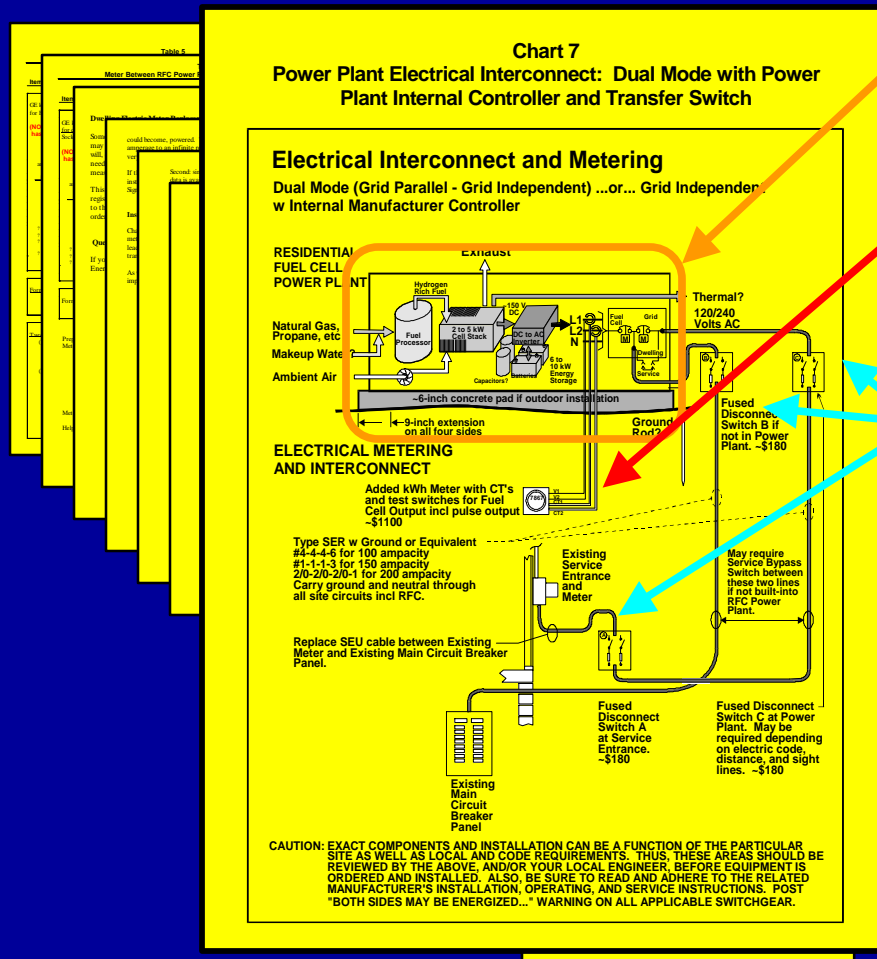
The stack of documents includes:

- Residential Fuel Cell Demonstration Program: Site Selection and Installation Planning Letter Report**
 - Instructions:
 - NREL ENVIRONMENTAL CHECKLIST
 - At the:
 - 1. Microturbine Demonstration Site Installation Cost Report
 - 2.
 - 3.
 - PLEASEN information:
 - PART A: Project Title
 - Awarded On
 - Center On
 - Project Manager
 - Project Manager
 - If you please
- Residential Fuel Cell Demonstration Program: Commissioning Letter Report**
 - At the point when you are ready to start your Residential Fuel Cell, you should have done the following:
 - 1. If you haven't done so, please finish up the Site_Select_and_Install_Plan_LR.doc that you started when the site was selected. By now this should have included all of that Letter Report's information including both the "red" and "black" areas. If during the installation, certain of the interconnects or plans changed, please update those portions of the Site Selection and Installation Planning Report and/or its illustrations and send the revised copy back in.
 - 2. Also, if you have not done so yet, please complete the Interconnect and Exams
- RESIDENTIAL FUEL CELL SERVICE REPORT**
 - 1. Date: / /
 - Site:
 - Mgr: ☐ Avista ☐ IFC ☐ H Power ☐ Global SolOx ☐ Plug Power ☐ FCT SolOx ☐ Other
 - 2. ☐ Instrumentation Problem ☐ Routine Inspection or Data Gathering ☐ Interconnect Problem ☐ Maintenance, machine still operating ☐ SHUTDOWN
 - 3. When did unit Shutdown? (Date) / / (Time) A.M. P.M. Caused By: ☐ Site fuel supply incident. ☐ Site grid incident. ☐ Water supply incident. ☐ Fuel Train ☐ Reformer ☐ Water Recovery or Treatment ☐ Fuel Cell DC Section ☐ DC Battery System ☐ Inverter ☐ Control System ☐ Thermal recovery ☐ Other: _____
 - When did you first arrive on site? (Date) / / (Time) A.M. P.M.
 - How many work hours were spent troubleshooting unit? (Hours) [] []
 - How much total delay, if any, was spent waiting for service instructions from mgr? (Days) [] (Hours) []
 - How much total delay, if any, was spent waiting for site mgr service to show up? (Days) [] (Hours) []
 - How much total delay, if any, was spent waiting for parts? (Days) [] (Hours) []
 - How many work hours were spent actually repairing unit? (Hours) [] []
 - Were manufacturer representatives on site? ☐ Yes, local service was (Company Name) ☐ Yes, mgrs own employee
 - When was unit repaired and ready to return to power output? (Date) / / (Time) A.M. P.M.
 - Optional: ☐ Don't count as Forced Shutdown! ☐ Don't count down time in Availability!
 - 4. Based on this single experience, please grade the following where applicable on a score of 0 to 10 where 0 = POOR 10 = EXCELLENT
 - Service Access to Fuel Cell [] [] [] [] [] [] [] [] [] []
 - Power Plant Design [] [] [] [] [] [] [] [] [] []
 - Mgr Field Service Manual Quality [] [] [] [] [] [] [] [] [] []
 - Ability to contact Mgr Product Support [] [] [] [] [] [] [] [] [] []
 - Mgr Product Support Knowledge [] [] [] [] [] [] [] [] [] []
 - Mgr Parts Shipping [] [] [] [] [] [] [] [] [] []
 - Mgr Field Service if on-site [] [] [] [] [] [] [] [] [] []
 - 5. Hours spent on-site. [] [] [] [] [] [] [] [] [] []

Already Accomplished (cont'd) . . .

 Extensive demonstration guidelines and barrier analysis:

 Electrical Interconnect



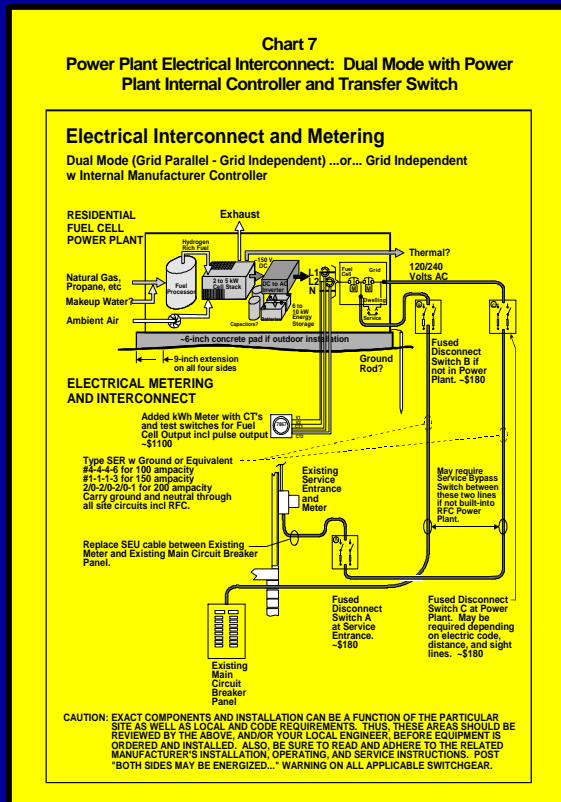
• Dual Mode RFC with Internal Transfer Device

• Custom CRN Demo Program Meter with special wiring

• Site Interconnect wiring and disconnect protection

Already Accomplished (cont'd) . . .

Typical Issues and Barriers Identified and Being Worked



- Grid Parallel export of power at night
- Remote disconnect / SCADA need
- Disconnects and location re code
- Inverter-to-Dwelling fault clearing
- Motor start capability
- etc
- Required fuel pressure vs codes
- Propane odorant level and variation
- Thermal recovery RFC loop vs safety/ codes
- etc

Already Accomplished (cont'd) . . .

 **Extensive demonstration guidelines and barrier analysis:**

Natural Gas / Propane (18 Pages)

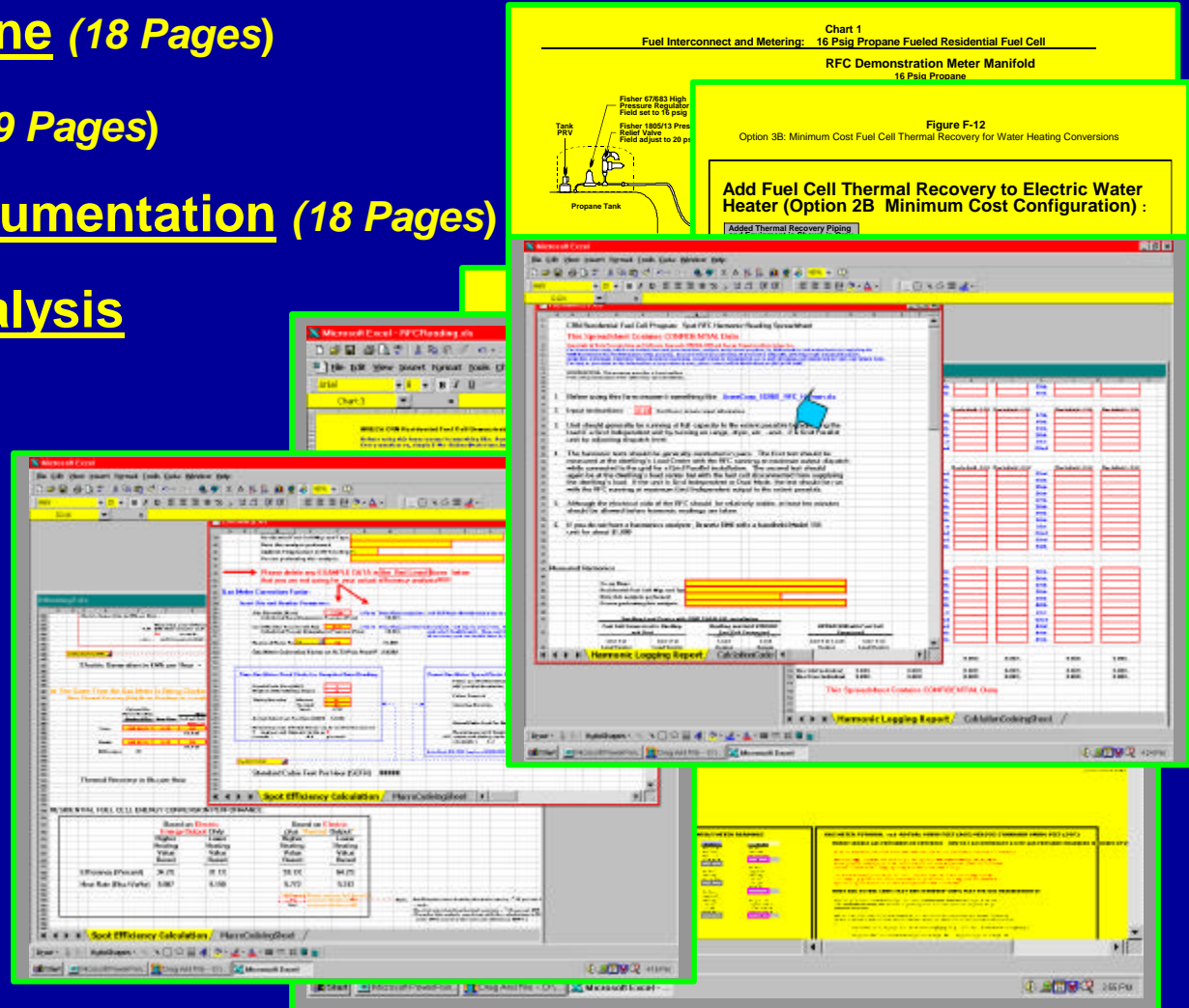
Thermal Recovery (9 Pages)

Data Logging / Instrumentation (18 Pages)

Meter Reading / Analysis

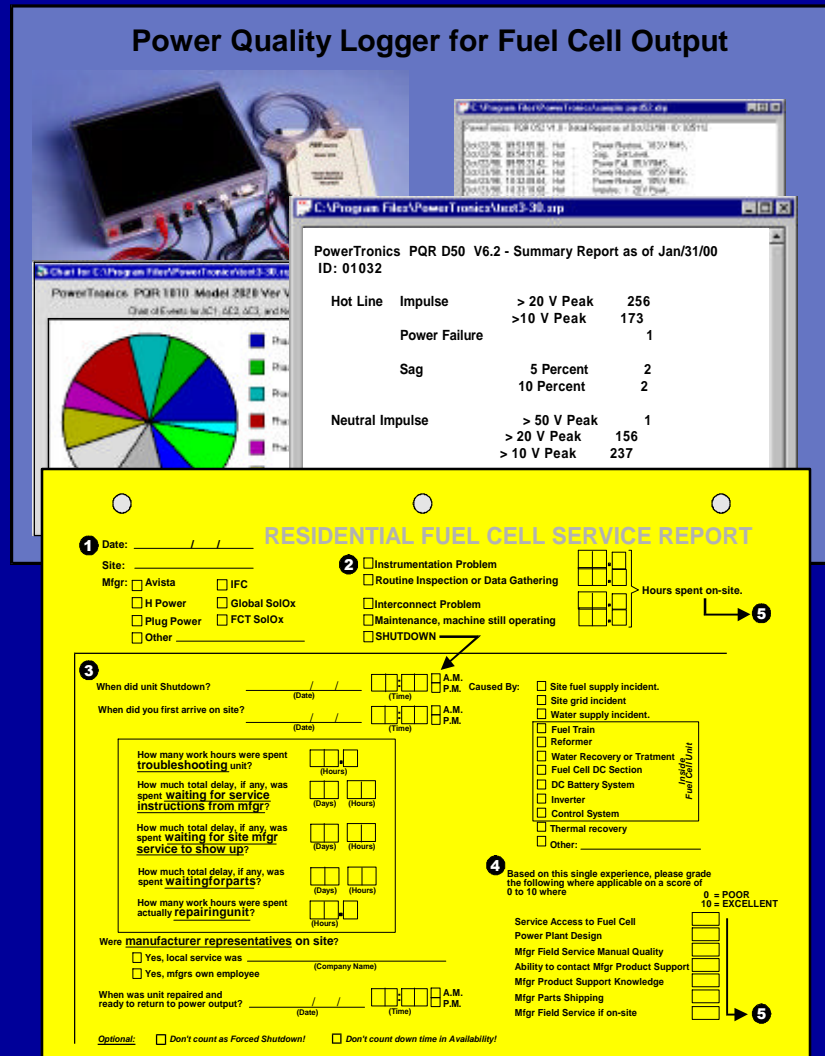
Efficiency Analysis

Harmonic Analysis



Already Accomplished (cont'd) . . .

Detailed Grid Interconnect Monitoring and PQ Instrumentation Protocols



- Computerized monitor to automatically detect, analyze, and categorize:

Grid Interconnect events

Customer Power Quality events

- Special reporting and analysis of Grid Interconnect incidents

Already Accomplished (cont'd) . . .

Organized active RFC Users Group

July, 2001 Meeting

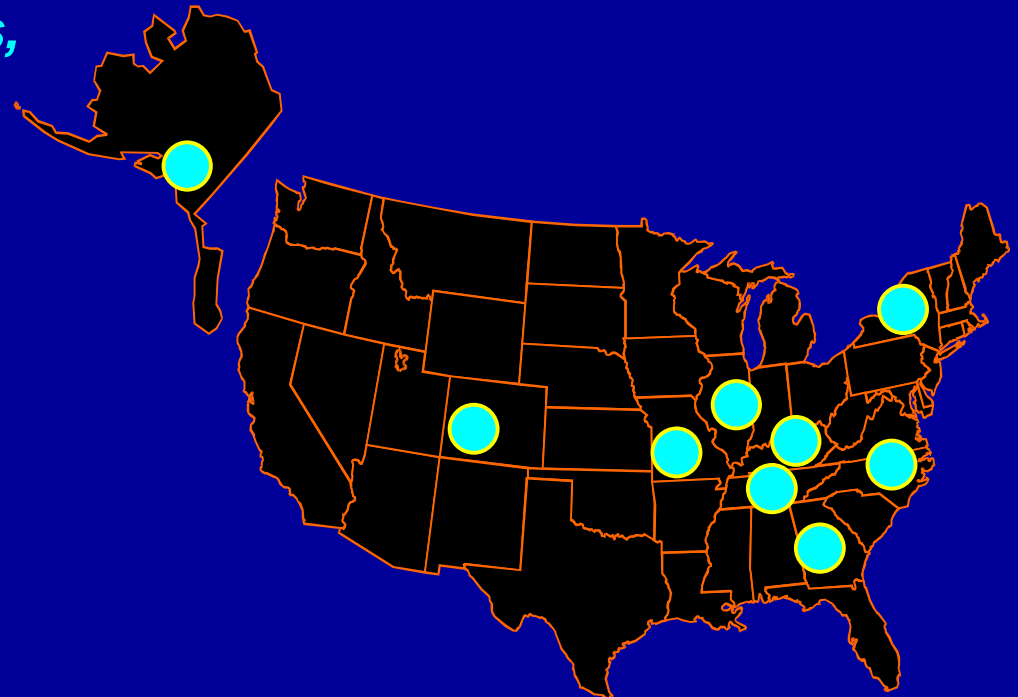
November, 2001 Meeting Georgia

- Technology Status Assessments: IFC prototype Avista
FCT SOx Plug Power
- Implement  Co-op Interconnect and Application Survey
- Interconnect Assessments:
 - Electrical Interconnect, metering and reporting
 - Propane / Natural Gas interconnect and metering
 - Thermal Recovery (CHP) options and metering
- Market entrance analysis and planning

Information Outreach . . .

Comprehensive spectrum of electric interconnects, climates, sites, and manufacturers

- Extensive feedback co-op to co-op and co-ops to mfgs
- Co-op demos include a broad range of public awareness programs and outreach (*commissioning ceremonies, open houses, local group presentations, site tours, brochures, bill stuffers, etc.*)

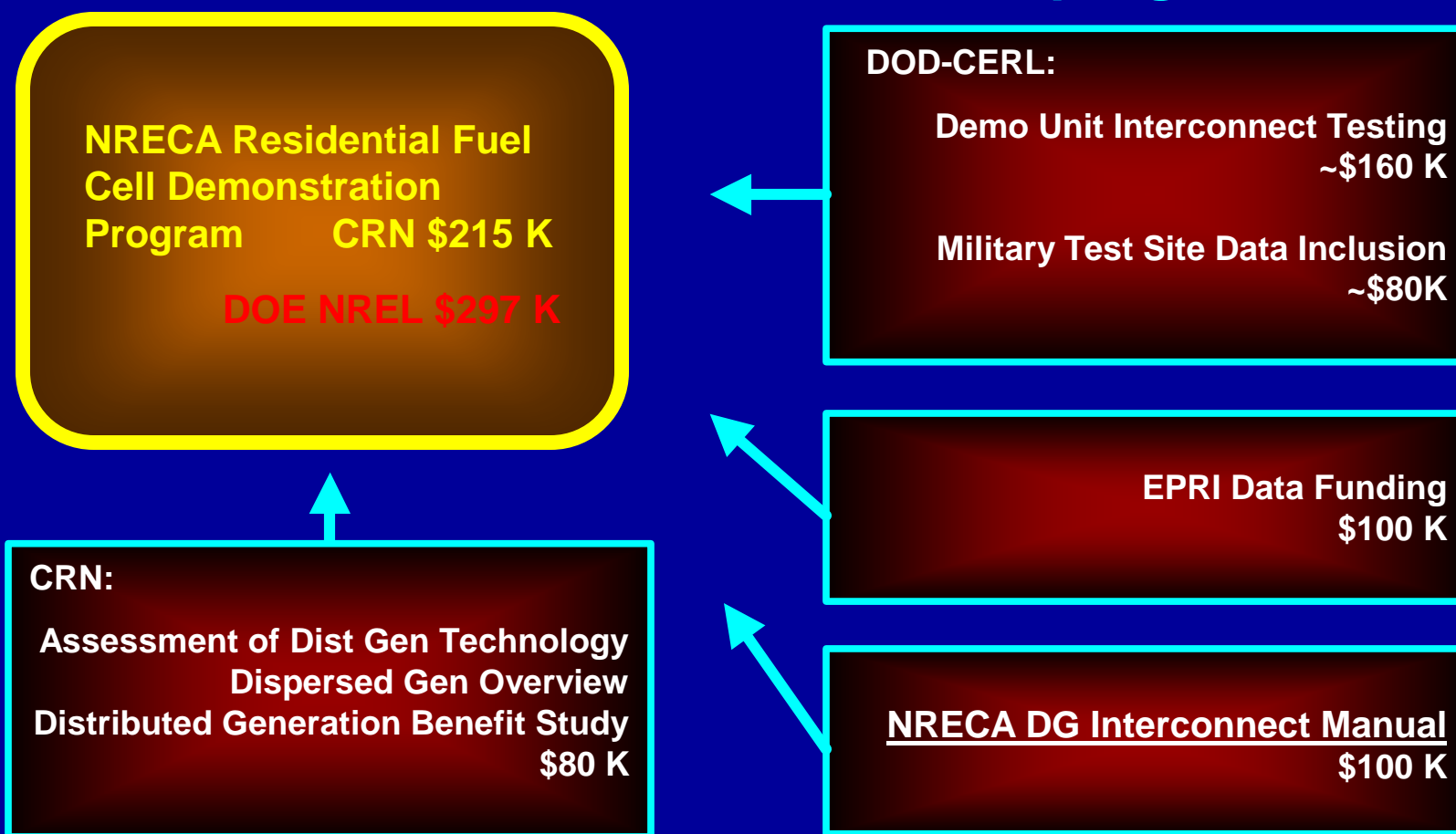


Information Outreach (cont'd) . . .

- Presentations to: co-op and industry working groups, DOE meetings, Joint Co-op/EPRI meetings, etc.
- RFC User Group meetings with manufacturers
- Significant joint effort with DOD-CERL
- Discussion underway with EPRI on joining Users Group
- Info and results posted on NRECA - CRN websites
- NRECA Annual Meeting displays/presentations reach over 10,000 senior co-op management and Directors

Enhanced Program Profile . . .

- Strongly committed Co-op participants
- Highly leveraged DoE funding
- Added enhancements outside demo program



Summary . . .

First Year's Major Accomplishments

- **Develop and implement RFC Handbook and related seminar**
- **Assess interconnect related barriers and implement guidelines**
- **Establish program reporting protocols First site reported**
- **Implement proactive RFC Users Group**

Projected Overall Program Results

- **Successfully demonstrate RFC DP grid interconnection in a real-world environment**
- **Remove or significantly lower RFC DP application barriers while substantially increasing public awareness**
- **Significantly increase manufacturer knowledge of practical DP implementation and needs via demo and Users Group**
- **Implement critically needed application and market assessments to broaden DP customer base**





Thank You

Courtesy NASA